UDC 666.3.061.5

PARTICULARITIES OF TINTING GLAZES, USING COBALT OXIDES, FOR BUILDING CERAMIC

V. A. Klevakin,[1] V. A. Deryabin,[2] and E. V. Klevakina[1]

Translated from *Steklo i Keramika*, No. 6, pp. 26 – 27, June, 2009.

The particularities of tinting glazes with regulatable tones blue are studied. The physical – chemical properties of glazes with a prescribed content of cobalt oxide and modifying oxides carrying active oxygen are determined. A glaze with optimum composition and high aesthetic and performance characteristics is synthesized.

Key words: building ceramic, glaze, coloring, cobalt oxide.

Various building materials making it possible to create individual architectural designs are now offered on the construction markets in large cities. The colors in greatest demand by architects are white, yellow, green, and dark blue. The Revda Brick Works now includes volume tinting of brick in yellow, rose, and brown hues.

A glaze coating makes it possible to obtain from classic terra cotta brick facing materials with a different color range. The glaze coating not only imparts high decorative and aesthetic effects but it also permits fighting against certain negative factors, such as salting-out. Cement producers are now encountering serious problems with raw materials. When certain cements are used on building façades a white plaque is observed; this plaque is difficult to remove and detracts from the architectural look. A façade made of glazed brick completely eliminates this problem, since the glaze is a protective coating. In addition, glazed-brick facades erected on houses are quite durable and long-lasting.

The objective of the present work is to obtain blue glazes with regulatable hues. This can be accomplished provided that the structural particularities of the glazes are known, which makes it possible to change the color of the glaze by changing the composition and the ratio of various oxides. Bivalent cobalt oxides in tetrahedral coordination impart a blue color to glaze while a rose color obtains with octahedral coordination. The coordination of cobalt can be changed by varying the content of modifying oxides.

White glaze with the following composition (wt.%) was chosen as a base: 40 – 45 SiO_2, 0.6 K_2O, 8 – 9 CaO, 6 – 7 MgO, 4 – 5 B_2O_3, 2 ZnO, 10 – 11 PbO, 12 – 13 Al_2O_3.

[1] Revda Brick Works, JSC, Revda, Sverdlovsk Oblast’, Russia.
[2] Ural State Technical University – First President of Russia B. N. El’tsin Ural Polytechnical Institute, Ekaterinburg, Russia.

Cobalt (II) oxide CoO in combination with litharge PbO was used to impart a bright saturated blue color to the glaze. Three compositions with different ratio of the cobalt and sodium oxides were prepared (Table 1).

The viscosity, CLTE, surface tension, and energy of adhesion of the glazes were determined. The investigations were performed at the Ural State Technical University (UPI).

The viscosity was measured by pressing an indenter into the sample. A plot of the function $\log \eta = f(1/T)$ was constructed to find the activation energy.

The activation energy of all compositions was calculated from the equation:

$$\log \eta = \log A + \frac{E}{2.3RT},$$

where η is the viscosity, A is a coefficient of proportionality, E is the activation energy of viscous flow, R is the universal gas constant, and T is the temperature.

As an example, the function $\log \eta = f(1/T)$ for a glaze with the composition 1 is displayed in Fig. 1. The values of the viscosity differ negligibly in the experimental range of the viscosity.

TABLE 1.

Composition	Content, wt.%			CoO : Na_2O ratio
	white glaze	CoO	Na_2O	
1	65.5	6 – 7	5 – 7	> 1
2	65.0	4 – 5	7 – 8	≈ 1
3	63.2	3 – 4	8 – 9	< 1

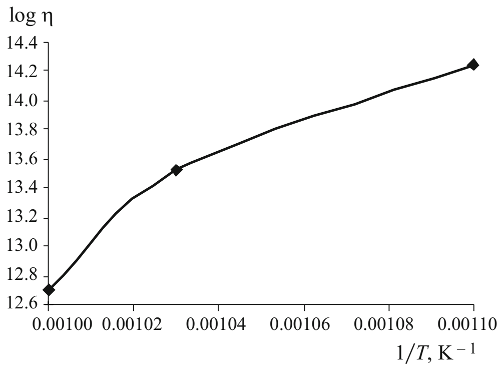

Fig. 1. Viscosity versus the reciprocal of the temperature for composition 1.

TABLE 2.

Composition	Energy of adhesion, kJ/mole	CLTE, 10^{-7} K^{-1}	Glaze density, g/cm^3	Surface tension, mN/m	Energy of adhesion, mJ/m^3
1	21.5	70	3.4	133	57
2	21.3	68	3.6	98	22
3	21.0	68	3.7	83	17

A quartz dilatometer was used to study the CLTE of the glazes. The results for the composition 1 and brick are presented in Fig. 2.

The CLTE is practically the same for all three compositions — 68.1×10^{-7} K^{-1}. The CLTE of the glazes is somewhat higher than that of brick.

The surface tension and energy of adhesion of the experimental glazes were determined by the stationary drop method using plots [1]. A diagram of the apparatus for determining wettability and adhesion is shown in Fig. 3.

The energy of adhesion is calculated from the equation:

$$W_a = \sigma_{liq}(1 + \cos\theta),$$

where σ_{liq} is the surface tension of the sample and θ is the wetting angle.

The physical – chemical properties of the experimental glazes are presented in Table 2.

For the glazes studied, a change of the composition has practically no effect on their viscosity in the experimental temperature range. Judging from the activation energy, the structural unit of viscous flow is relatively small. This is due to the presence of lead and boron oxides in the glazes. The CLTE is practically the same for all compositions and somewhat greater than that of brick. The CLTE has virtually no effect on the quality of the coating.

The maximum values of the surface tension and energy of adhesion are found in glazes with composition 1. As the

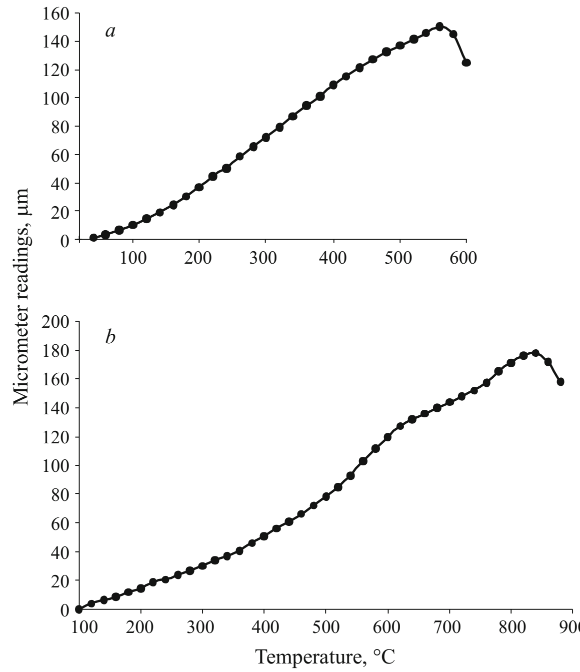

Fig. 2. Variation of the dimensions of a sample glaze with the composition 1 (*a*) and brick (*b*) versus temperature.

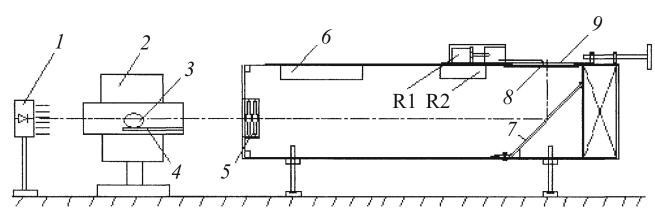

Fig. 3. Apparatus for investigating the phase wettability and adhesion: *1*) block of superbright LEDs; *2*) furnace; *3*) sample; *4*) backing; *5*) block of lenses; *6*) measuring apparatus; *7*) mirror; *8*) screen with pointer; *9*) measuring frame; R1, R2) resistors.

sodium oxide content in the composition increases, the surface tension and the energy of adhesion decrease.

Regulation of the color tones of a glaze by varying the ratio of cobalt and sodium oxides made it possible to synthesize a glaze with the optimal composition (composition 1), whose blue color was brighter and more saturated and which had a bright lustrous surface. A commercial batch of bricks with high performance characteristics was produced using composition 1.

REFERENCES

1. S. I. Popel', Yu. P. Nikitin, and S. M. Ivanov, *Curves for Calculating the Surface Tension from Drop Size* [in Russian], Izd. UPI, Sverdlovsk (1961).